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PREDICTION AND MEASUREMENT OF DIRECT-NORMAL SOLAR IRRADIANCE: A CLOSURE EXPERIMENT

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Direct-normal solar irradiance (DNSI), the total energy in the solar spectrum incident on a plane perpendicular to the Sun's direction on an unit area at the earth's surface in unit time, depends only on the atmospheric extinction of sunlight without regard to the details of extinction - whether absorption or scattering. Here we describe a set of closure experiments performed in north-central Oklahoma, wherein measured atmospheric composition is input to a radiative transfer model, MODTRAN-3, to predict DNSI, which is then compared to measured values. Thirty six independent comparisons are presented; the agreement between predicted and measured values falls within the combined uncertainties in the prediction (2%) and measurement (0.2%) albeit with a slight bias ($\sim 1\%$ overprediction) that is independent of the solar zenith angle. Thus these results establish the adequacy of current knowledge of the solar spectrum and atmospheric extinction as embodied in MODTRAN-3 for use in climate models. An important consequence is the overwhelming likelihood that the atmospheric clear-sky absorption is accurately described to within comparable uncertainties.